SCIENTIFIC PROBLEMS IN THE CONSTRUCTION OF MUSICAL INSTRUMENTS

S. Ramanathan

My object is to place before you some aspects to be considered by a manufacturer of musical instruments.

The Upper Plank, Meru, Bridge and Kudam (Resonating bowl)

1 (a) *Upper Resonating Plank:* The *tambura* and the *vina* have certain features which are almost identical. Take the upper resonating plank. As I understand, the shape, the thickness, the curvature and the formation of grains of the upper plank, its purflings and *kannu villai* play a more dominant part in producing a right vibrant tone than the height of the bowl.

In countries abroad, the raw wood is first dried and seasoned before it is used for making instruments. But here the bowl, the *dandi* and the upper plank are carved when the wood is still wet for easy and proper working. The parts are then allowed to dry and fitted together. It is, however, desirable to assemble the parts of the instrument with the upper plank while the upper plank has some low water content. As we go on playing the newly finished instrument, the sound vibrations made on the slightly moist plank probably change the direction of the little fibres. As a result of this, the instrument gives a very rich sound. We know that the wood with close and parallel grains is excellent for use as an upper resonating plank to obtain a rich vibrant tone. Probably, the new arrangement of the fibres of the upper plank due to playing, helps in producing the rich tone. So, as we fit in the upper plank, allowance must be made for its drying and the consequent loss in weight.

When selecting wood for the upper plank from different kinds of wood or from the same kind of wood grown in different forest areas, the time allowance for the drying has to be considered separately. This technique- of knowing the correct percentage of drying is found now by experience and intuition only. But there is also an instrument which can determine electrically the content of moisture in the timber.

(b) *Wolf-Note:* In some *vina*-s a harsh wolf-note can be detected. while playing the middle gamut on the instrument. This wolf-note is encountered when the frequency at the particular fret on which the instrument is played coincides with the natural frequency of the upper plank. Players strive to avoid playing the wolf-note. How to get over the wolf-note is a problem. It could be done either by making the *kannu villai* heavier or lighter, or by changing the area of the surface of contact of the feet of the bridge on the upper plank, or by increasing the distance between the feet of the bridge and by keeping them asymmetrical.

(c) *Bridge and Meru:* The bridge and the *meru* (nut) have their function in affecting the quality of the instrument. The upper surface of the bridge is wide and curved. This means that the string is not in contact with the bridge at a point only, as in the violin or guitar, but covers a larger surface. The *jiva* thread in the *tambura* broadens the contact area still further. In the *vina* we do not use the *jiva* thread. But to produce the *jiva* effect, the upper contact area of the metal portion should be properly ground to form the correct slope. The depth and width of the groove on the *meru* where the string rests should also be very carefully adjusted.*

(d) *Resonating bowl:* It is necessary to think of reducing the size of the instrument to facilitate easy transport. The length of the *dandi* and the breadth or area of the upper resonating plank cannot be very much altered without seriously affecting the tonal quality. But there is no appreciable change in the sound, even if the height of the bowl is less than half its normal height. Still, care should be taken while carving this smaller *kudam*. Suitable compensation has to be made by changing the thickness of the wall of the bowl or by adding weight in some places of the wall, and the length of the *dandi* is cut somewhere in the middle with a strong hinge provided to fold the *dandi*. With the foldable *dandi* and the height of the *kudam* reduced to less than 6 inches and the weight to less than 3 kilograms a really portable *tambura* is possible.

2. **Seasoning:** As observed earlier, *vina*-s and *tambura*-s are made while the timber is very wet. So natural seasoning of the wood has to be

*See, for further discussion of the problem C.V. Raman, On some Indian Stringed Instruments, *Proc. Ind. Asoc. Cult. Sc.*. 7 (1921-22) and B.C. Deva, *Psychoacoustics of Music and Speech* (1967) Ch. 4

started after several parts like *kudam*, *dandi* and upper plank are made. That means we have to stock a number of semi-finished instruments or parts of instruments for a long period, resulting in locking up large capital, also leading to an inability to meet the demand. For quicker seasoning, we must find a suitable method by electrical radiation or chemical means.

3 **Strings:** In the past, it is said, guts were used as strings. Now-a-days steel, brass and phosphor-bronze wires are being used. We also use coiled strings. The basic necessity for the string, if it should produce rich over-tones, is that it should be a highly flexible filament of perfectly elastic material with a uniform cross section throughout. It is well-nigh impossible to come by such a string which combines the required degree of elasticity and flexibility. Materials such as steel and animal tissue are close approximations to this ideal. Now matters such as the upper partials and their intensities of the vibrating string come in for our consideration. For producing a note of low frequency — *mandram* and *anumandram* in *vina*, and *mandram* and *panchamam* in *tambura* — we use a brass string instead of a steel one, for the simple reason that steel is more stiff or rigid than brass. The rigidity inhibits the formation of upper partials.

Musicians of old sang in a high *sruti* (key). Now-a-days most of them take the middle "C" of the piano or one or two tones below the middle "C" as their basic *sruti*. So we have to use much thicker brass wire for *mandram* and *panchamam*. But again the rigidity of the brass wires increases with thickness. This has necessitated the choice of a string of the right diameter or thickness for *mandram*, etc. Coiled strings are the answer. For making a suitable coiled string for a particular pitch and length it is not enough if we just take into account the total thickness of the finished coiled string. By keeping the total thickness or mass per unit length of the wire constant for a given pitch, and varying the thicknesses of the core and outer winding wire and also the material of which the wire is made, we can observe how diverse overtones of different strengths are produced. Herein is a field that affords plenty of scope for experimentation and arriving at a ratio of the thickness of the core and the outer wire of the coiled string that would give suitable results. By drawing the finished coiled wire through the hole in the die and making the outer surface smooth, and covering the steel wire with thin silk or rayon, before winding the copper outer wire, we can change the tonal colour of the string. Again while the coiled string is made, the inner core ought to be stretched to the operating condition and then only the outer wire should be tightly wound over it.

A string of a particular thickness and length speaks well over a very small range of frequency. Now we must consider the tension of the string at this frequency. Let us call this the optimum tension of the string. At

the optimum tension the sound produced is at once sweet and sustaining and the plucking noise is at its lowest. By using the same string the *sruti* can however be raised or lowered by about two tones (*srutis*) by increasing or decreasing the tension alone. But the sound produced is not satisfactory or dies very soon and, further, the adjustment of the *jiva* is very difficult. So it is advisable to select a proper string to work at optimum tension for a given *sruti.*

In Western countries, they have the standard pitch and so the strings for different instruments are scientifically made and standardised. In our country every vocalist sings at a pitch of his own. Further, the speaking length of a *tambura* for a particular pitch is not standardised. I believe, that to a certain extent, the speaking length of the *tambura* for a given pitch can be standardised and the thickness and quality of the strings determined.

So all these factors such as the ratio of the thickness of inner and outer wires of the coiled string, the length of contact of the string over the bridge, the slope on the bridge, the thickness of the *jiva* thread and the depth and width of the groove on the *meru* govern the total quality of the tone of the instrument.

4 **Gourd (Tumba):** Yet another factor is the choice of the gourd for the *vina*, which is fixed near the *yali* (dragon head). The gourd is not to be mistaken as a piece of support for the *vina* on the thigh. The proper way to play the *vina* is by holding it almost vertical, so that the gourd is near the left ear. Now even the softest tone can be heard clearly along with the sound of the strings which vibrate sympathetically. The tone colour and the volume of the sound of the *vina* are greatly influenced by the size of the gourd and the diameter of the hole at the bottom. Great care must be exercised in choosing the right type of gourd for the *vina.* Of late, natural gourds are not easily available in South India. So a papier mache model of the gourd is used as a substitute. But it serves only as an ornamental piece. Besides making the instrument heavier, it lowers the intensity of the sound of the *vina* and changes the tone colour also. It does not sand the extremes of weather and loses its shape. I happened to read recently a German journal that a violin was made of aluminium. But when the suggestion was taken up by me in an experiment and I fitted a *vina* with a gourd made of aluminium and played, a tinny sound was observed. To muffle the tinny sound this gourd was painted outside and lined with thin cork sheets inside. I have also made some successful experiments in shaping a wooden gourd as a substitute for natural gourds.

5 **Fretting:** Let us consider the fretting of the *vina.* The metal frets of the *vina* are fixed to the fret-board by means of a special wax compound. This compound consists of bees wax, paraffin wax, some resinous substance and hardening material like lamp black, etc. If we have to make

any finer adjustments of the *melam**, for instance, to change the *sruti*** value of the *swara* or to bring the fret nearer to the string or press it downwards, the hard wax compound has to be made soft and maleable by exposing it to the sun. Now the frets can be moved on either side or raised and lowered from their positions according to the requirements of the *sruti*** value of the *swara* or the touch of the fingers. The wax, besides holding the frets in the proper position performs the specific acoustic function of preventing the energy of the string from passing directly to the fret-board. The wax compound works all right in the climatic conditions of South India plains. But it melts or becomes very soft during summer in places like Delhi and the wax becomes brittle and the whole wax bed along with the frets comes off the board at temperatures below 4 °C.

How to solve this problem? Can we do away with this wax compound completely? If the frets are fixed directly to the fret-board by means of screws, the sound colour of the *vina* is completely changed. So, I tried the following method of fretting. Here the frets are fixed on pairs of aluminium channels by means of bolts and nuts. The pairs of channels are first fixed to a plastic sheet which in turn is fitted to the fret board. By this arrangement the frets can be adjuted by loosening the bolts. Now the sound quality is far better than when the frets were in direct contact with the board. Even now we cannot do away with the wax compound. In order to get the original colour of the *vina* tone and to conform to the features of the *vina* of the usual type, the aluminium channels and a portion of the frets had to be covered with the same wax compound. But the instrument becomes rather heavy and the volume of the sound lowered slightly. However for instruments sent abroad, I have adopted the above method so that the *melam* can hold up well under different climatic conditions. Instead of the aluminium channels, we have to try plastic extrusions of different make. We also have to find a compound which will be capable of not only withstanding any extremes of temperature but can be softened when heat is applied at the required portion. If some synthetic adhesive, like araldite, is used it may fix the frets to their position permanently. Owing to the wearing down of the upper surface of the metal part of the bridge, the frets and the strings by constant use, and due to the shrinkage of the instrument and the consequent slight distortion caused in the *dandi*, the *sruti* value of the frets in position will undergo a slight change. Then it may not be possible to shift the frets for adjustments. Here is a field offering scope for study and research.

6. **Facility in Playing:** To increase the facility in playing or handling the instrument the gap between the upper surface of the frets and the

---

* *melam* refers to the placement of frets correctly.

** *sruti* here refers to microtonal variation.

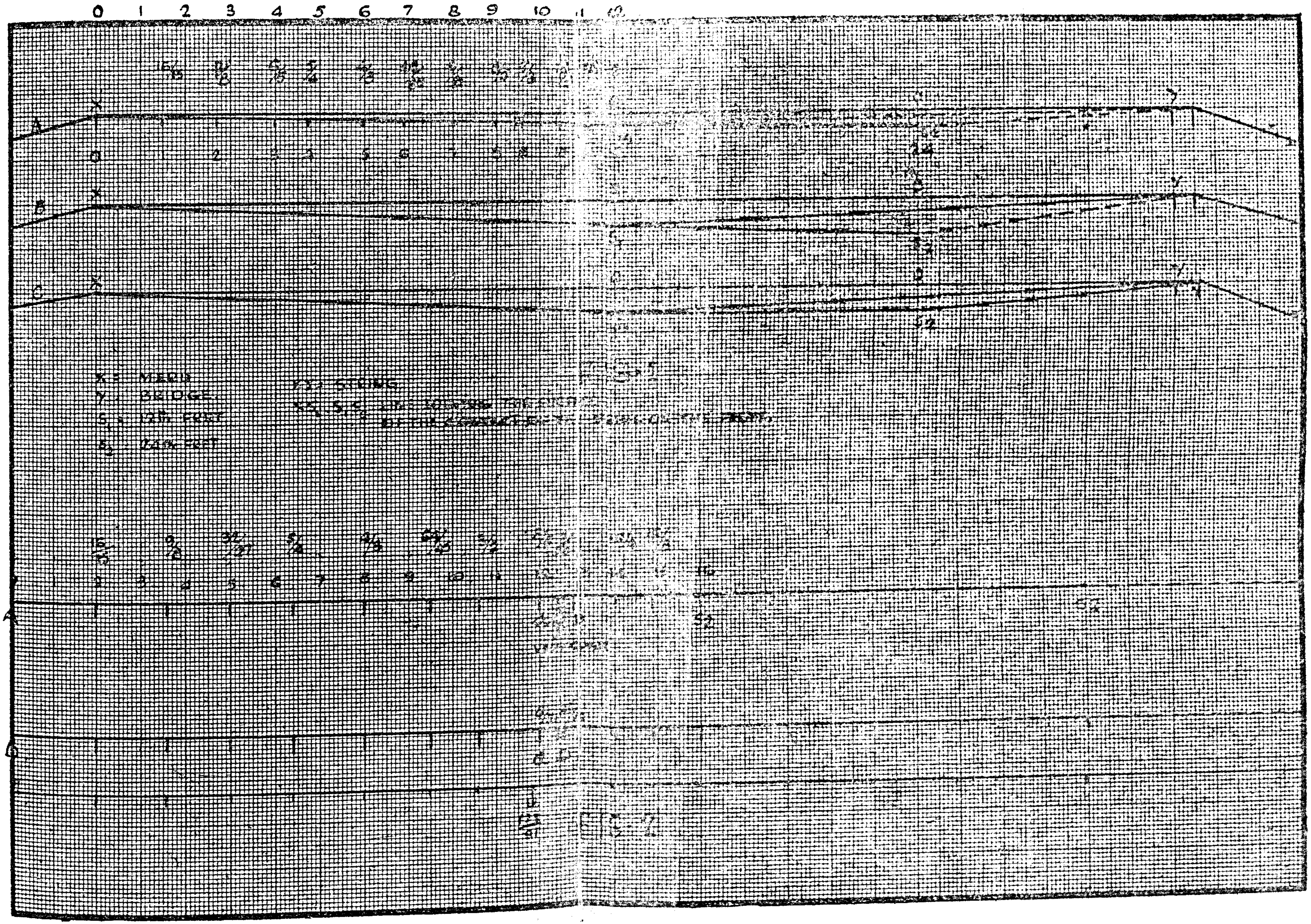
string should be as low as possible. But at the same time the string should not come into contact with the frets when plucked—of course, except at the point at which the string is pressed. [Refer to graph.] In figure A let us take XY, the line of the string, as the line of reference. From the *meru* (X) the 24 frets can be arranged towards the right end of the fret-board in such a way that the frets slope downwards. Now the line XS_2 joining the upper surface of the frets forms a small angle with the line XY. Point S_2 is the 24th fret. If we keep the gap OS_2 very small the string comes into contact with the frets, when plucked. To avoid this contact of the string with the frets, the line XS_2 should subtend a wider angle at X. In figure B the frets are so arranged that the gap OS_2 is twice that in figūre A. Now the string, when plucked vibrates without touching the frets. As the gap at QS_1 in Fig. B is greater than in Fig. A, even if the string vibrates in one loop the mid-point of the string does not touch the 12th fret, S_1. But the gap between the frets and the string on the upper gamut, especially from the 16th to 24th fret, is considrably increased and more pressure is needed to press the string on the frets. So, much effort is needed in playing this part of the gamut.

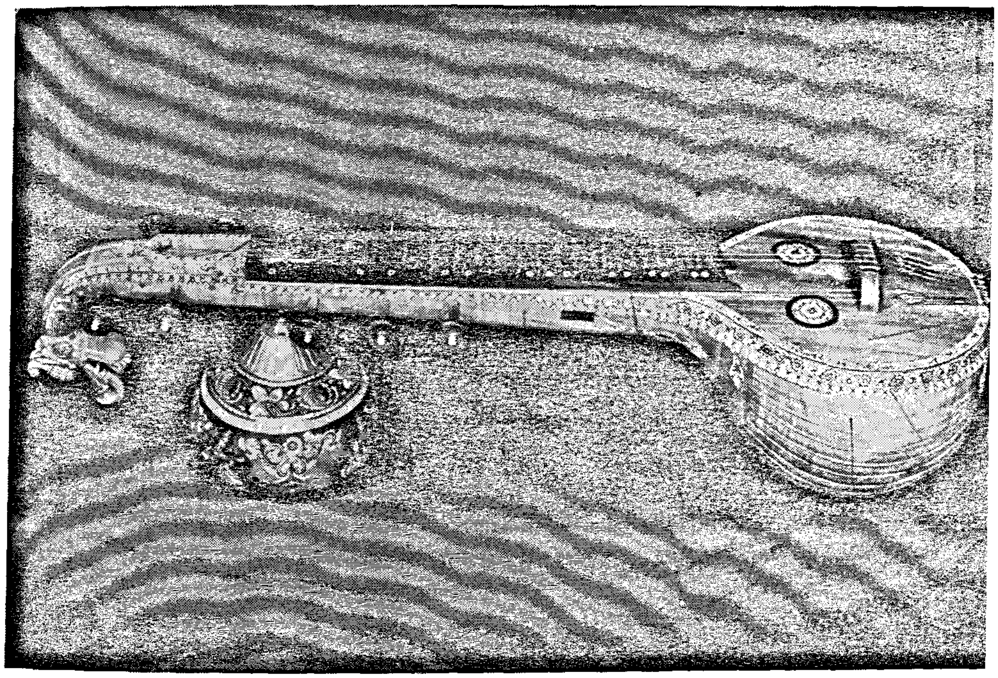
Let the frets be arranged as in figure C i.e., the first 12 frets beginning from meru sloping down (XS_1) and from 12th to 24th fret sloping upwards (S_1 S_2). Now the gap between the string and the 24th fret is reduced (OS_2), making the instrument easy for playing in the upper gamut. Further as the gap between the string and the frets, 9 — 15, are not altered very much, the string will not touch these frets while vibrating. It does not matter if the gap is wide at the mid-portion of the fret arrangement, because much pressure is not needed to press the string on the middle portion. With this arrangement the *spuritam* can be produced very easily. The sound produced when gliding the fingers both ways over the string after plucking is also pleasing to the ears, (*yeru* and *irangu jaru*, i.e. ascending and descending glides).

7 **Melam :** Then the problem of choosing the frquency for the twelve notes of the frets comes in. We have to choose from the following 16 notes.

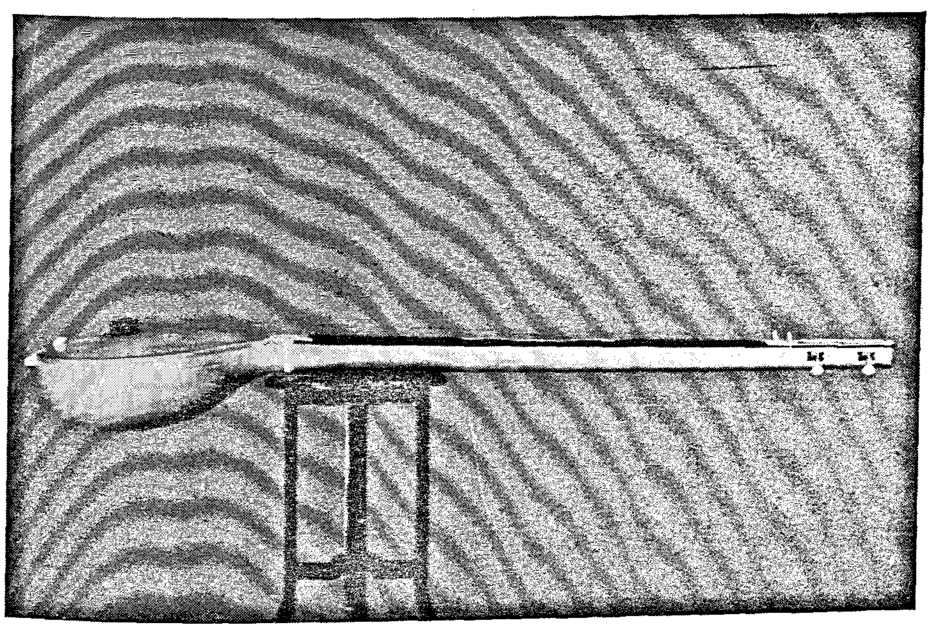
r	R	g	G	M	
16/15	(10/9 or 9/8)	(32/27 or 6/5)	5/4	4/3	
m	P	d	D	n	N
(45/32 or 64/45)	3/2	($\frac{128}{81}$ or 8/5)	(5/3 or 27/16	16/9	15/8)

There is no difficulty in fixing r, G, M, P, n, and N. Out of the five pairs of R, g, m, and D which frequencies have we to select? Let us take d and D. If 8/5 and d and 5/3 D are chosen the two frets come very close together, affecting the facility in fingering (refer to Graph II -

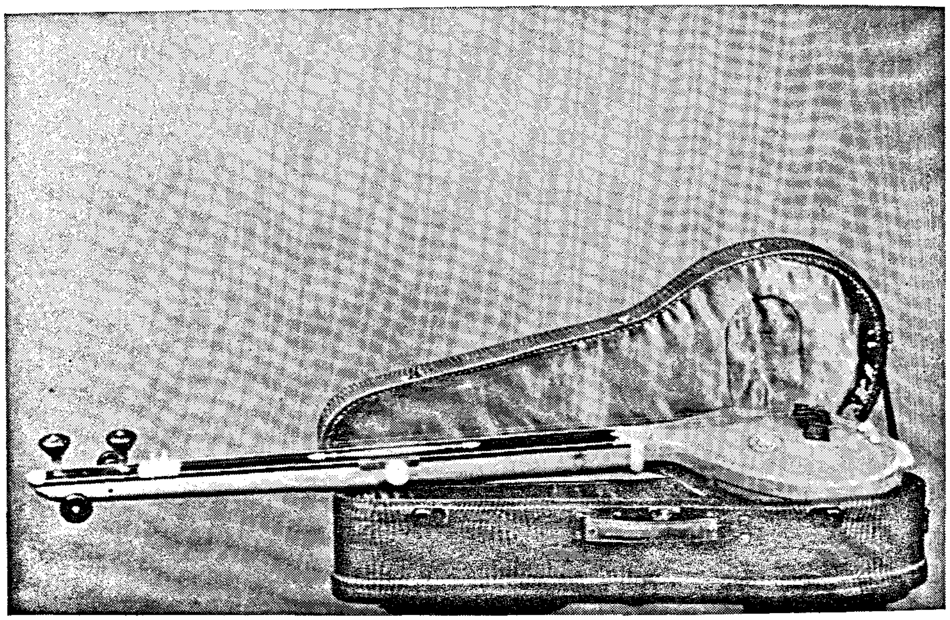

0 1 2 3 4 5 6 7 8 9 10 11 12
A
B
C
X = NECK
Y = BRIDGE
S_1 = 12th FRET
S_2 = 24th FRET
XY = STRING



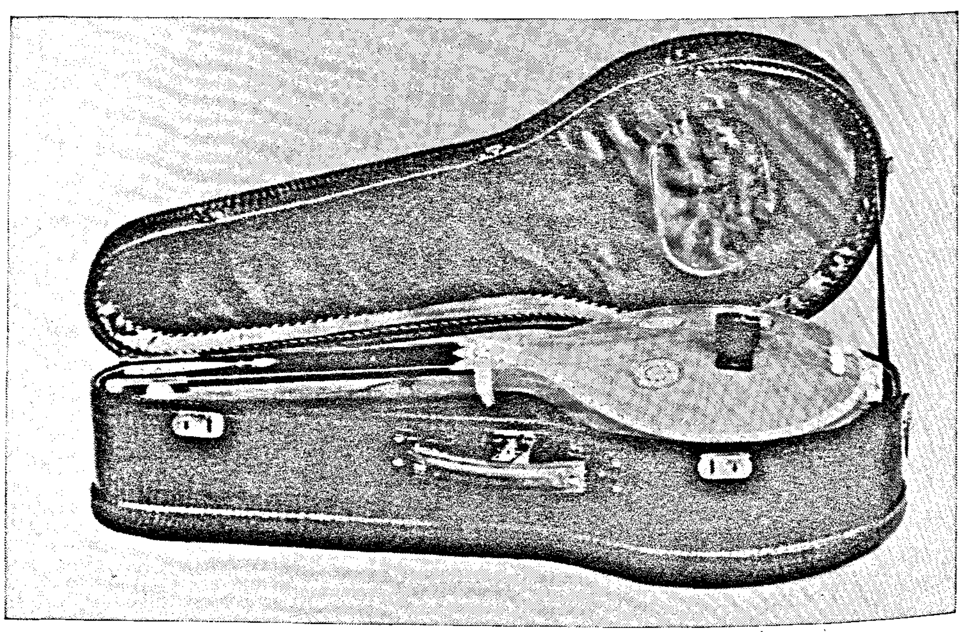
Vina



Folding Tambura



Folding Tambura opened out



Tambura folded

Figure A). Then are we to choose the frequency 27/16 for D? or 128/81 for d (refer to Graph II Figure B). Would it not be better to standardize the *melam* by deciding these twelve frequencies? Or is it better to leave it to the individual player?

There are also other problems in making provisions for easy stringing and for micro-adjustment of the tension of the strings and in the selection of wood for the pegs, the right type of adhesives and polish. And we should not forget that some of the decoration or inlay work or purflings done on the instruments play an important part in the improvement of the tonal quality.

These observations and findings are personal and they have been accepted by a number of musicians. I would very much like to have these finding verified with the help of modern scientific devices like Sweep Spectrum analyser, wave and harmonic analyser and such other instruments. In short, any change in design and consequent change in quality is largely the result of skill in workmanship based on experience plus 'cut and try' method of experimentation conducted at length. Now it is possible to approach problems of this character from an engineering point of view. Now-a-days acousticians with the help of modern sound measuring electrical instruments can make qualitative and quantitative measurements. This procedure when followed could lead to marked advance in the quality of musical instruments. And this could be achieved in a short time too. Whatever experiment is done on a musical instrument and whatever change is made in it, we should not forget that music and musical instruments are inseparably connected.